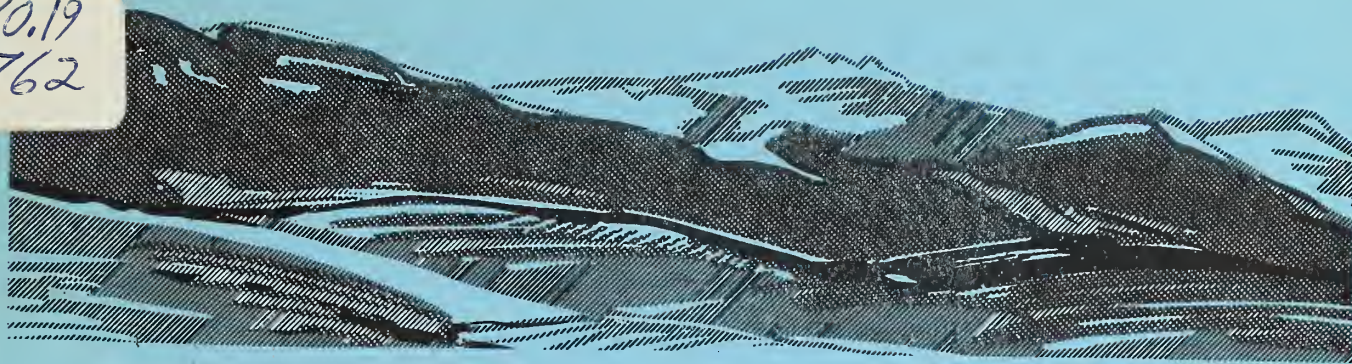


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INDEX

A Partial Literature Review on the
Use of Fertilizers to Increase Pro-
duction on Rangelands1

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STATEMENT OF PURPOSE

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This publication is printed primarily to inform professional range administrators of important range improvement and management developments and findings. These "NOTES" may include extracts of published papers, unpublished preliminary reports of research work, unpublished reports on administrative studies and personal observations or suggestions of other range administrators. No claim is made as to the accuracy or completeness of studies or conclusions drawn.

All who read these RANGE IMPROVEMENT NOTES are encouraged to submit material for publication, or suggestions for improving its usefulness. Full credit will be given for any material used.

265

A PARTIAL LITERATURE REVIEW ON THE USE OF FERTILIZERS TO INCREASE PRODUCTION ON RANGELANDS ,

by

E. F. Schlatterer *

The increasing demand for beef generated by an affluent society has caused renewed interest in raising the forage production capability of our western ranges. Among the techniques often mentioned to increase production is the use of fertilizer.

This paper is a partial literature review of some of the more important recent research on the use of fertilizers to increase production on rangelands in the northern and central Rocky Mountain West. Emphasis was placed on research that might have application to the Intermountain Region of the Forest Service encompassing southern Idaho, western Wyoming, Nevada, and Utah. No attempt was made to make this a complete and thorough literature search.

The response to the use of fertilizer on rangelands in the Rocky Mountain West and adjacent areas has been varied depending on soil conditions, kind, amount and season of precipitation received, the nutrient used in the study, the plant species involved, and many other factors. Often results obtained one year cannot be replicated the next or over a long period of time. Some of the more consistent successful results have been obtained in the Northern Great Plains and the Pacific Northwest.

The literature has been subdivided into those studies dealing with a single application of fertilizer, and those dealing with a series of multiple applications of fertilizer. Papers dealing with these two subdivisions are aggregated by location into the Northern Great Plains, Pacific Northwest, or Intermountain areas.

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I. SINGLE APPLICATION OF FERTILIZER

A. Northern Great Plains

Black (1968) compared the effects of fertilization with nitrogen and phosphorus on the production of crested wheatgrass and native Great Plains grasses in both wet and dry years in northeastern Montana. He found that production increases of crested wheatgrass were greatest the year the fertilizer was applied, with successively lesser increases in the next two years following a single application. The native grasses, on the other hand, did not increase very much in production the year the fertilizer was applied, but showed the greatest response the second year and tailed off the third. In this study the native grasses were more productive than crested wheatgrass in years with favorable rainfall.

In Alberta, Canada, Johnston et al (1968) reported better responses to N+P fertilization on seeded range than on native range. The residual effect of a single application of fertilizer declined in the third year.

Smoliak (1965) in studies conducted on the short grass plains in Alberta, Canada, obtained significantly increased yields each year over an eight-year period from single applications of manure, straw, fertilizer, and straw plus fertilizer. In this study a very heavy application of NPK was used (300 lbs. N; 150 lbs. P_2O_5 ; 300 lbs. K_2O per acre).

Others who have demonstrated increased yields on rangelands with residual effects over a period of years from a single application of fertilizer in the Northern Great Plains include, Nichols and McMurphy (1969), Black and Wight (1972) and Power (1972).

Power (1972) after studying the fate of nitrogen fertilizer in a Northern Great Plains ecosystem concluded: "Collectively these results indicate that addition of high N rates to grasslands results in saturating the capacity of the soil-plant system to immobilize N. The system can then be maintained in an N-saturated condition if annual fertilizer additions plus mineralization equals immobilization plus irreversible losses."

Cosper et al (1967) found a botanical composition change from predominately forbs and short grasses to western wheatgrass and short grasses from a single application of nitrogen to native ranges in eastern Wyoming.

B. Pacific Northwest

Among studies conducted in the Pacific Northwest, Hubbard and Mason (1967), and Mason and Miltimore (1969) found residual effects up to five years on only a few of their fertilizer trials on native ranges in British Columbia. Mason and Miltimore (1972), however, reported yield increases by beardless wheatgrass for a ten-year period following a single application of nitrogen.

C. Intermountain

In contrast to the results obtained in the Regions mentioned above, most studies using a single fertilizer application in the Intermountain area have been unsuccessful or at best marginally successful.

Eckert et al (1961) determined the effects of fertilization on the yield of crested wheatgrass in westcentral Nevada occupying a converted sagebrush-wheatgrass site in the 12-inch precipitation zone. "In phase 1, the N-90 treatment gave a significant yield response in each of the first 4 years after application. The N-30 and N-30+P-100 treatments gave significant yield responses in each of the first 3 years after application. The P-100 and S-100 treatments did not give significant response in any year."

"In phase 2, application of N-60 resulted in a significant increase in yield at 2 locations the first 2 years after fertilizer application."

Eckert et al (ibid) analyzed the cost involved in obtaining increased production as follows: "On the basis of 15 cents per pound of nitrogen, a 3-year increase from 30 pounds of nitrogen cost approximately 28 dollars per ton of crested wheatgrass. The 4-year response from 90 pounds of nitrogen costs approximately 37 dollars per ton of grass." They concluded from their study that "Fertilization of the sites described with the rates and materials used would not be practical." Their analysis was done at a time when fertilizer was relatively low in price when compared to today.

Hull (1963), found that neither nitrogen nor phosphorous fertilizer increased yield on mountain rangelands in northeastern Utah and southeastern Idaho.

Bleak (1961), also working at high elevations in central Utah, was able to increase yields of smooth brome but "... available soil moisture and climatic conditions largely determined the increased forage production." He states further that "Although accelerated soil erosion has been widespread, most of these soils are potentially productive and the limiting factors appear to be available soil moisture and local climatic conditions."

Bowns (1972) fertilized native high mountain meadows (10,200 ft.) in southwestern Utah with nitrogen and phosphorus. Significant increases in production were obtained from a single fertilizer application over a period of two years. By the third year production differences were not significantly different from the controls. The highest production in this study was obtained from the application of 60 lbs. each of nitrogen and phosphorus. However, the production increment from adding 60 lbs. of P to 60 lbs. of N was only slightly more than 100 lbs. of increased production over that obtained from the nitrogen alone.

Cook (1965) conducted a series of fertilizer studies at several locations in central and northern Utah. All but one production study was conducted using seeded exotic grasses. Nitrogen and phosphorus were used, but only nitrogen significantly influenced production consistently. On mountain meadows phosphorus improved yield but considerable less so than did nitrogen.

Although in all cases statistically significant increases in production were obtained the first year after the application of nitrogen fertilizer, carryover effects were reduced drastically after the second year on grazed pastures. Of five production studies reported, one had no carryover, two had a two-year carryover, one was not measured after the first year, and one had a four-year carryover. However, in the latter case, the site was protected from grazing for the 4-year period. All other sites were grazed by livestock.

It appeared from Cook's studies that nitrogen fertilization of mountain meadows and of crested wheatgrass ranges (if accompanied by rest from grazing in the latter case) were the most promising. Cook (ibid) stated: "Before extensive areas are treated on a practical scale, however, tests should be made on small plots to see if the benefits received will justify the cost."

II. MULTIPLE APPLICATIONS OF FERTILIZER

A. Northern Great Plains

Rogler and Lorenz (1957) annually fertilized native range in the Northern Great Plains over a six-year period with 30 and 90 lbs. of nitrogen and obtained consistent production increases. In spite of grazing pressure which was heavy in one pasture and moderate in another, they obtained an average of between 15 and 22 lbs. of forage per pound of nitrogen applied. The 30-pound rate was more efficient in this regard than the 90-pound rate. Rogler and Lorenz concluded that "Two years of fertilization of a heavily grazed pasture at the 90-pound rate of nitrogen did more to improve range condition and production than six years of complete isolation from grazing."

Smika et al (1960) conducted a study on crested wheatgrass, Russian wildrye, and brome grass in the Northern Great Plains in which the effects of annual applications of barnyard manure, nitrogen, nitrogen plus phosphorus, and nitrogen plus phosphorus plus potassium were determined over a seven-year period. Highly significant yield increases were obtained annually over the seven-year period. Crested wheatgrass produced the greatest yield increases followed by brome grass and Russian wildrye. However, in evaluating the efficiency of these three species in recovering nitrogen, they concluded: "The low nitrogen recovery percentages obtained by these grasses show that they are very inefficient users of fertilizer nitrogen."

Goetz (1969) studied the changes in composition and yield of native plains grassland species on four different soils on the Northern Great Plains in response to annual nitrogen fertilization over a three-year period. He concluded that the ability of the vegetation on a site to respond to nitrogen was closely correlated with the inherent production potential of the site. In addition, species responded quite differently to nitrogen. Western wheatgrass, threadleaf sedge, plains reedgrass, and fringed sage increased in basal cover and density, while blue grama, and needle-and-thread tended to decrease.

In a companion study Goetz (1970) studied the growth and development of the species on these four range sites in relation to nitrogen fertilization. One important finding in this study was that for grasses and sedges: "the degree of early leaf drying, in the presence of adequate soil moisture, is apparently delayed at the higher levels of fertilization but becomes more rapid later in the growing season." Such a reaction might have a detrimental influence of shortening the green feed period.

Lorenz and Rogler (1973) found that the yields of all fertilizer treatments decreased as the frequency of harvest increased. The yield reductions were greatest when the harvest sequence included harvest early in the growing period in June.

B. Pacific Northwest

Mason and Miltimore (1959) obtained increases in yield of native bluebunch wheatgrass of 65 percent in 1957 and 154 percent in 1958 following the application of 60 pounds of nitrogen in the spring of 1957 and again in the late fall. The site was a native sagebrush-grass type after the sagebrush had been cut with a mower and left in place.

Patterson and Youngman (1960) applied nitrogen fertilizer to native grasslands of the Palouse Prairie in Washington. They obtained increases in the production of desirable grasses with rates up to 40 pounds per acre, but at higher rates (60 or 80 pounds per acre) no additional increments were obtained. One complicating factor was the increase in production of cheatgrass. In one year as much as 82 percent of the total 3919 pounds of forage produced on sites fertilized with 80 pounds of nitrogen was cheatgrass. They concluded that high rates of nitrogen fertilizer would promote serious ecological regression.

Patterson and Youngman (ibid) also determined the response of seeded crested wheatgrass to fertilizer and found that the average yield over a five-year period was doubled by use of 40 pounds of nitrogen per acre. This rate produced 40.5 pounds of herbage per pound of nitrogen applied, which was a significantly greater rate of return than either higher or lower rates of application. They state that: "It should be noted that the doubling of production of crested wheatgrass with 40 pounds of N resulted in about 1100 pounds gain in yield - the native grasses doubled their yield at the same rate of nitrogen but produced only 550 pounds of additional herbage." In their conclusions they state:

With N at about 15¢ per pound, the rancher would have a fertilizer cost of about \$6 for the 40 pounds of N that was the most efficient rate on either of the two range types. The 1100 pounds of crested wheatgrass could be obtained for about \$6 or at the rate of approximately \$12 per ton. Similarly for \$6, one could produce 550 pounds of native grass (plus some cheatgrass). This would be at the rate of slightly less than \$20 per ton of the desired herbage. Good range management practices would allow use of only about one-half of this increased production. The only cost calculated so far is that of the nitrogen added. Costs of application would need to be included. Under present costs and prices it would seem that only the rancher in areas receiving at least 13 inches of precipitation annually with crested wheatgrass range would benefit by nitrogen fertilizer application.

C. Intermountain

Sneva (1963) summarized 10 years of fertilizer studies conducted at the Squaw Butte Experimental Station near Burns, Oregon. Attempts to fertilize native sagebrush-grass vegetation were totally unsuccessful. Sneva (ibid) states: "On a sagebrush site in poor condition, which has been fertilized annually since 1954 and sampled for understory response in the years 1954, 1955, and 1962, 15 pounds of N per acre has increased the herbage yield by only 6 pounds per acre." He also noted nitrogen caused changes in the plant composition. "On the improved native range site, the composition of cheatgrass was increased on all fertilized plots at the expense of the perennial plants."

Considerably better results were obtained on crested wheatgrass, big bluegrass and Whitmar wheatgrass seedings. Here too results were variable from year to year depending on precipitation.

Sneva (ibid) states: "Over a 3-year period, 1953 to 1955, the mean yield of crested wheatgrass was increased 84 percent by June 1 of each year, when fertilized with 20 pounds of nitrogen per acre in the previous fall." Although this is a favorable response, ". . . the fertilizer cost of producing an additional ton of herbage in this study was estimated at \$23."

The addition of 30 lbs. per acre of nitrogen annually over a five-year period produced a mean annual increase of forage of 1146 pounds per acre of big bluegrass and 949 pounds per acre of Whitmar wheatgrass. In years of lower than normal precipitation as little as 31 and 285 pounds per acre increase were obtained by fertilization of big bluegrass and Whitmar wheatgrass, respectively. In such years the cost of fertilization did not produce an economic return. The average cost of producing an additional ton of forage based on the five-year average was \$8 and \$9.50 for big bluegrass and Whitmar wheatgrass, respectively.

Sneva (ibid) concluded: "The results speak for themselves - nitrogen fertilization is most apt to return profits from sagebrush-bunchgrass range when it is used on high yielding stands of introduced grasses harvested at maturity. "

Sneva and Hyder (1965) reported on the responses of other introduced exotic species to nitrogen fertilization including Siberian wheatgrass, hard fescue, sheep fescue, crested wheatgrass and Fairway wheatgrass. Of the above species, only Siberian wheatgrass was a good responder to nitrogen fertilization.

Sneva (1973a) presented the results of a 13-year study on attempts at producing additional spring and fall herbage by nitrogen fertilization of crested wheatgrass. He found that "Nitrogen fertilizer at 30 lbs. per acre increased 13-year mean spring, regrowth, and fall yields of crested wheatgrass 83, 29, and 78 percent , respectively, above control plot yield." However, the efficiency of return was low. "Each pound of N applied returned approximately 8 lbs. of additional spring herbage. When regrowth yields were included, this return increased to 12 lbs. "

Sneva (1973b) found there was no difference in yield if fertilizer was applied in fall, winter, or spring, and only slightly better results from urea than from ammonium nitrate when applied to crested and Siberian wheatgrasses.

Kay and Evans (1965) studied the effects of nitrogen fertilization on a mixed stand of cheatgrass and intermediate wheatgrass in northeastern California. The site was a sagebrush-squirreltail site. They found that nitrogen increased the growth of cheatgrass, while greatly reducing the amount of intermediate wheatgrass in the stand. Grazing appeared to increase this effect.

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The following are some conclusions that were drawn regarding the potential applicability of the use of fertilizer to rangelands in the Intermountain Region of southern Idaho, western Wyoming, Nevada, and Utah.

1. Nitrogen is the only fertilizer element that has been used successfully to increase production of rangelands in the Intermountain Region.
2. On dryland ranges, seeded exotic grasses respond to nitrogen fertilizer much better than native species.
3. Marginally acceptable production increases are obtained on dryland ranges seeded to exotic grasses with an average annual precipitation of 13 inches or more, and then only when the annual precipitation exceeds the average.
4. Carryover of fertilizer effects into succeeding years from a single application of nitrogen fertilizer are usually limited to less than three years on grazed ranges.

5. The soils on some ranges in the Intermountain Region are not deficient in nitrogen.
6. Cheatgrass responds much better than perennial grasses to nitrogen fertilizer. The increase in yield of cheatgrass may reduce the amount of perennial grasses in the stand through competition. Grazing pressure may accelerate the rate of decline in production and density of perennial grasses while favoring cheatgrass production.
7. On high elevation wet meadows, on sites deficient in nitrogen, both native and exotic species produce marginally acceptable production increases in some years following the application of nitrogen fertilizer.
8. The high cost of fertilizer and application, the lack of consistent year-to-year production increases, and the lack of consistent carryover of production increases from one year to the next over an extended period on grazed sites, raise a serious question as to the economic practicability of using nitrogen fertilizer to increase production on rangelands in the Intermountain Region.

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A good safety record is NO ACCIDENT ! ! !

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Envy is the art of counting the other fellow's blessings instead of your own.
Harold Coffin, AP

